AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology
—AND—
Allied Branches of Study.

Vol. I. **JUNE, 1884.** No. 2.

CONTENTS.

EDITORIAL NOTES.

STUDY ON THERMOMETERS "FRONDES" 41
STUDY OF THUNDER-STORMS.....41
PRECISE TERMINOLOGY.....42

CURRENT NOTES.

CHESTER CO. (S. C.) GEYSER.....43
SIGNAL SERVICE CIRCULAR.....44
BALLOON ASCENSION.....44
FOREST FIRES.....44
INTERNATIONAL ELECTRICAL EXHIBITION.....44
SERIES OF TORNADIC STORMS.....45

ORIGINAL COMMUNICATIONS.

THE WINDS AND CURRENTS OF THE EQUATORIAL ATLANTIC—W. M. Davis.....48
THE RAIN-FALL OF NEBRASKA—S. R. Thompson, 56
THE OAKVILLE TORNADOES—A. J. Phinney, M.D.,58
THE DRY AND WET BULB THERMOMETER "FRONDE"—H. A. Hazen.....63

TRANSLATIONS, ETC.

THE ARCHED SQUALLS OF THE INDIAN OCEAN —M. Millot.....65
NEW VIEWS ON THE CONSTRUCTION OF ANEROID BAROMETERS AND MANOMETERS—Dr. Schwirkus, 66
SCOTT'S METEOROLOGY—W. M. Davis 70
LITERARY NOTES.....73
CORRESPONDENCE.....76

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THE AMERICAN

Meteorological Journal.

VOL. I. DETROIT, JUNE, 1884. NO. 2.

EDITORIAL NOTES.

WE publish in this number the results of a study on what the author calls thermometers *frondes*. In the next number we expect to have a translation of Dr. Assmann's study of this instrument for hygrometric purposes. The instrument is called in French *fronde*, which is a sling, and in German it has the corresponding name of *Schleuderthermometer*. Why not translate this into English and call it by the Anglo-Saxon descriptive name *sling*, making it a sling-thermometer or a sling-psychrometer?

ELSEWHERE will be found a circular from the Chief Signal Office, the object of which is to effect a more complete study of our thunder-storms. The study of local storms is of the highest importance, and has not attracted as much attention as it deserves. The thunderstorm occupies a place in the series of related phenomena which begins with the formation of a cumulus cloud and finds its climax in the tornado. In their severer forms thunderstorms become tornadic in character. A careful study of them will undoubtedly throw much light on the more violent species and their frequency, usual mildness, and striking character make them favorable objects for study. In this very promising line of work the

Chief Signal Officer needs the aid of many observers, and individual meteorologists scattered over the country can hardly be of greater service than by co-operation with him.

ONE of the first requirements in careful study is a precise terminology. The words of technical meaning used in the description of weather phenomena should have sharp definitions, and should never, if avoidable, be employed in two senses. For example, the wind should be said to *veer*, or, in more nautical parlance, to *haul*, when it shifts in what Dove called the normal direction of rotation; that is, from north through east, and south to west (in this hemisphere); while it should be said to *back* when it shifts in the opposite direction. The two effects are now well known to depend chiefly on the attitude of the observer with respect to a passing cyclonic storm. The wind *hauls*, if he stand on the right of the track; it *backs*, if he stand on the left.

In recent years a serious confusion has arisen in the frequent confounding of *cyclone* and *tornado*. Cyclone was proposed by Piddington, about 1840, to name those large storms of the Indian Ocean, in which the winds blow over a large area in spiral courses towards a center of low pressure. The term now properly includes also the hurricanes of the West Indies, and the typhoons of the Chinese seas, all of which are often grouped as *tropical cyclones*, or better, as cyclones of tropical origin. The term is also properly applied to the numerous storms that cross our country from west to east, and then pass northeastward over the Atlantic. To speak of these disturbances simply as *storms* is correct, but rather indefinite, for storms should include all winds other than those of the great planetary or permanent, and continental or periodic circulations. To call our larger storms *barometric depressions* gives a name to only one of their well known characteristics. Although of greater diameter, they are in no significant respect different from the storms to which Piddington first applied the name, *cyclone;* their designation by this word is fully justified; it should be generally accepted, but it should as well be properly limited.

Tornado is an older word, of Spanish origin, that was first applied to the violent local storms in the equatorial seas between the trades, west of Africa, where they are very common. The word came into general use in this country at the time when Redfield and Espy gave so notable an impulse to our study of meteorology; it was then again

applied to violent local storms, very similar in action, if not in origin, to those of the equatorial seas; since that time it has been in frequent use. But of late years the newspapers, and hence their readers also, have shown an increasing preference for the large-sounding word, *cyclone*, and now they are continually misapplying it to the smaller storms, so that *tornadoes* is becoming almost obsolete in popular writing. It is fully time that an effort should be made to check this erroneous use of so good a word.

The Signal Service gives its authority to the use of the words as here defined: we should be glad if one of their tornado circulars were prepared to advocate the distinct use of the two words, and addressed to the agents of the Associated Press. The error might thus be soon overcome. In the mean time, let the matter be made as public as possible. There can be no doubt whatever that the two species of storms are quite distinct in their typical development; the question is simply how they shall be named. We should be glad to have an expression of opinion in the matter from our correspondents; especially from those who differ from us.

CURRENT NOTES.

THE Canadian government is about to explore the exits to Hudson's Bay. The marine department has sent an officer to St. John's, Newfoundland, to procure a suitable vessel for the Hudson Bay service. It is probable that the expedition will reach the straits about the beginning of July, so as to watch the movements of ice.

THE Chester Co. (S. C.) "volcano" or "geyser" so generally noticed in the newspapers some weeks ago, proves to be, (as we learn from W. W. Anderson, M. D., of Stateburg,) only a spot in the woods where an active imagination can perceive an under ground roaring. It is perhaps due to a subterranean stream. Verily, distance lends enchantment to the view.

THE earthquake on April 22nd, from the Thames river to Bury St. Edmonds, does not seem to have been very severe. The occurrence of an earthquake in England is not surprising as their relative frequency there is not small. In fact England lies in the line of the streak of territory subject to earthquakes which stretches up from Etna and Vesuvis toward Hecla.

THE United States revenue steamer Corwin sailed May 3d, from San Francisco for Alaska with Lieut. Doty and party, who have been specially detailed by the Treasury Department to explore the new river discovered last year in Alaska by Lieut. Stoney. The latter left three weeks ago on the schooner Ounalaska under government orders to continue the explorations of the river.

WE have the following note from the Hydrographic Office at Washington: The captain of the brig 'Romance' from Navassa to Baltimore, reports that on the afternoon of April 9th, in lat. 32° 30′ N., long. 73° 30′ W., he experienced an extraordinary hail storm-lasting about an hour. Some of the hail-stones which fell on his decks were measured and found to be from an inch to an inch and three-quarters in diameter. The wind at the time of the storm was strong from the N.W.

A FEW days of dry weather in March or April are usually enough to make considerable danger of forest fires. We have had extensive ones this spring. Early in April much turpentine timber was destroyed in North and South Carolina. In the middle of the month the fires appeared in the sandy counties of Georgia and did much destruction. At the end of April and beginning of May they occupied considerable territory from New York to Virginia and did considerable damage in the lower peninsula of Michigan. The destruction of forests by these fires is very extensive annually and while we can not prevent the dry weather which makes the woods of spring and fall like tinder, nor the high winds which spread the fire some more efficient means could probably be devised to prevent the origin of the fire.

THE International Electrical Exhibition is to be held under the auspices of the Franklin Institute at Philadelphia from Sept. 2nd to Oct. 11th, of this year. Meteorologists will be interested in Class VI, Section IV, which includes electrical registering apparatus, and in Section V, which is devoted to Terrestrial Physics. This section embraces atmospheric electricity, terrestrial magnetism and apparatus used by governments for weather-signal stations.

In connection with the exhibit of instruments, the Institute desires as complete an exhibit as possible of all publications relating to electrical science. They desire any publications, reprints, papers, or notes on or relating to electricity. These publications will be classified in a printed catalogue and be retained in the Institute as a memorial library of the exhibition. Communications on this subject are to be addressed to the Committee on Bibliography, Franklin Institute. Philadelphia, Penn.

APRIL 18th, Mr. E. D. Hogan—a professional aeronaut—made an ascent from Jackson, Michigan and, after about 15 hours in the air, landed hear Fort Wayne, Indiana. While he had no instruments with him, he feels certain of the approximate accuracy of the following facts of meteorological interest: There was no current at the surface. Form 1,000 to 4,000 ft. elevation the balloon was slowly drifted N. W.; from 4,000 to 10,000 ft. S.; from 10,000 to 15,000 ft. southeast with some variations. A due easterly current was struck at 15,000 ft. and in this the balloon remained 7 hours. Descending he was driven S. then W. then at 1,000 N. W. when he descended reaching the ground at 7 A. M. The uppermost current carried him at about the rate of5 miles an hour, the others at about twice that velocity. The uppermost current was extremely cold, and Mr. Hogan adds that he has found this current in all his ascents.

SIGNAL OFFICE—WAR DEPARTMENT.

Circular No. 4. *Washington, March 1st, 1884.*

IT is desired that during the summer of 1884 a few simple facts be collected relating to the important subject of thunder-storms. To this end post-offices and

other centres have been selected, over a limited extent of country, at distances of about 30 miles. Each station, it will be readily seen, forms an important point in the network of stations, and by a comparison of these observations it is hoped that valuable acquisitions may be made to our knowledge of these frequent accompaniments of tornadoes. Each thunder-storm should have some note made of it, in order that there may be no gap in any region.

The following instructions are given for guidance in making observations: Each card will have sufficient space for two storms. Give town, county, state, time (whether "mountain," "central," "eastern," or some city), and name of observer.

Thunder-storms twelve hours apart may be taken as separate storms.

Upon the occurrence of thunder give in the appropriate spaces month and day, and as near as possible, the time of first and last thunder connected with the storm. Frequently after a storm has passed there will be muttering of thunder, but care should be taken to, as far as may be, watch the single storm.

Give the direction from which the storm appears to be coming, as shown by threatening sky, lightning flashes or thunder peals. Also, the direction towards which it goes.

Give time of beginning and ending of rain, with amount, if possible.

If the rain continues rather heavy more than two hours after the loudest thunder has passed, it may be marked "more than two hours."

The amount of rain can be measured, with a common rule, after it has been caught in a pail or empty tomato can with vertical sides.

All observations of hail, size of stones, &c., are very important.

Give directions and force of wind before and after the thunder-storm; for the force adopt the scale, calm, light, moderate, brisk, high, very high, hurricane or tornado.

If you have a thermometer give the shade temperature, or temperature on north side of house, a little before the storm reaches the station as well as after it has passed.

Note, also, if on any day heat-lightning is seen, the date, time of appearance, and direction.

If there is not time for a full report, give date and time of severest part of thunder-storm. Please do not fail to make some note of every distinct thunder-storm that passes over, or within ear-shot of, the station.

Observations should begin immediately upon the receipt of the cards.

Please return one of these cards on July 1st and another on September 1st, even if there is no record other than town, county, state, and name.

This circular is issued with the sanction of the Postmaster General.

If you know some one in your immediate neighborhood who takes an interest in meteorology and would be willing to report, you are at liberty to hand these cards to him.

W. B. HAZEN,
Brig. & Bvt. Maj. Gen'l,
Chief Signal Officer, U. S. A.

"Postage-free cards, which may be used for recording these data, will be sent any one who is willing to make the record and who will send his name to the Chief Signal Officer of the army.

WE again have an unfortunate amount of information concerning tornadoes. Resuming the numbering of the last issue of this Journal:

III. For this series (March 25th) the set of four preliminary charts made by Sergeant Finley of the Signal Service are now before us. The charts are of the

same character as the preceeding sets. The tornadoes recorded on them are twenty in number scattered through a territory limited by Indianapolis, Youngstown, Ohio, Central Alabama and Kittyhawk in North Carolina. Their direction is between N.E. and E.N.E. From central Alabama to Kittyhawk extended nearly a continuous row and North Carolina had six out of the twenty.

During the 25th an area of low pressure of elongated form passed N.E, the center travelling during the day from central Missouri to near Saginaw Bay on Lake Huron. The long axis of the area was directed nearly N. and S. and it carried in advance of it on its S.E. quadrant a region marked by contrasts of temperature and nearly saturated with moisture. The passage of this part of the area was every where marked by thunder, hail, or rain-storms. The distance of the tornado-paths from the center of low pressure is from 150 to 750 miles.

The casualties connected with this series is approximately, 77 killed, 298 wounded, and nearly a million of property destroyed.

For the two following clippings we are indebted to H. S. Jewett, M. D., of Dayton. They are from the *Dayton Daily Journal* of March 26 and 27. The first gives the account of an eye-witness of the formation of the funnel, and is as follows:

"He was a passenger on the north-bound narrow gauge express which left Lebanon at 5:05 P. M., and and obtained a good view of the cyclone as it appeared, and the damage done in various localities. He states that shortly after leaving Lebanon he observed the storm clouds rising in a southwesterly direction from that place and driving rapidly north and east. At that time he observed a small white cloud surrounded by a dense dark mass, which grew until with an alarming swiftness it developed into a seething white cloud, rather balloon-shaped, and forming the center of a black back-ground of clouds. He admitted that he was terrified, as were the other passengers, and as he had witnessed a tornado before, he at once recognized the perculiar formation of the clouds. It appeared to remain high above the earth until in the vicinity of Oak Ridge, a small station, twelve miles from the city on the narrow-gauge, when rain began to fall rapidly, and then the cyclone seemed to touch the ground, rising and falling, in continual undulations like a vessel at sea. Here was where the most damage, as far as heard from, was done, and the loss is heavy."

The second appears to relate to the disappearance of the funnel and is also from an eye-witness.

"Near the farm Riley Shank, about one mile southwest of Mt. Zion, the cyclone seemed to swoop down upon the earth and for a short distance tore along through woods and fields, when it again arose and made its next appearance near Beaver's Station. Mr. Horace Ankeny states that he was on the road leading to the Little Miami River bridge at that point, and saw the dark clouds with a grey funnel-shaped mass in the center. The wind whistled by him and the grey mass, then higher in the air, suddenly swooped down upon the river, the tongue striking the water and licking it up like a huge monster and blowing it high in the air. Trees and fences disappeared in the cloud of water, and timber began to drop all around the country. The cyclone was then going northeasterly, and as he followed it with his eye, he saw it rush upon the bridge, and in an instant that structure was flying high in the air. Huge timbers shot up over one hundred feet, and the debris mixed with limbs of trees and water filled the air. The bridge had hardly met its fate before the surging wreck entwined itself around the tobacco shed and stables of Mr. Trebein, and whirled them to destruction. On it went with its terrible mission, tearing houses and barns down as for as he could see. Another man farther east on the pike, said that a short distance from Beaver's the balloon-shaped

monster took an easterly course and struck a patch of timber, cutting a path-way through it about fifty yards wide. When nearly through this it spent its force, and divided into two parts, each retaining the balloon shape, when it disappeared among the clouds as quickly as it at first appeared. Following its course, on all sides beams and limbs of trees were seen sticking in the mud standing on end."

It is noted that the tornado, from Scipo to Woods and Darrtown, followed in the track of the "cyclone" of two years before.

IV. We publish in this issue the accaunt of a tornado of this series which destroyed Oakville, Ind.

V. Another series of storms passed over the Southern States on April 14. There were but few tornadoes and the energy was for the most part expended in excessively heavy rainfalls which extended from Louisiana to West Virginia. The principal wind-storms were in Harris Co., Georgia and at Grenada, Mississippi.

VI. A tornado did great destruction in S.W. Ohio on the afternoon of April 27th. It passed over Jamestown, destroying about half of it. At the same time tornadic storms were reported from Missouri. The formation of the Jamestown tornado was seen by many and all agree in the essential details. As the most detailed we insert the following description from the *Dayton Daily Journal* of May 2, which we owe to Dr. Jewett.

"A description of the cyclone of last Sabbath, as given by a trustworthy eye-witness who stood and carefully observed its formation, not more than a mile distant, and who was not more than two hundred yards from the center of its path of destrnction as it swept by carrying everything with mad vim before it, has given to this form of storm a special interest and dread. He said that while he had watched the progress of many a hard-fought battle with the roar of cannon, rattle of musketry, and clash of arms, nothing in his life that he had ever seen or heard was so grandly terrible as the sight and noise of the cyclone. It formed about one mile southwest of Carrollton, at a point just west of the Miami River, by two clouds coming together, one from the south and the other from the northwest. Both very low, but neither threatening in appearance until they collided. But then he says no language can fittingly describe their terrible movements. For fully five minutes, like two mighty giants, blackened with fury, in fierce battle they contended for the mastery. Plunging into and through each other, boiling, writhing, roaring, and dropping nearer the earth. The terror of the whole scene being augmented by the deep-throated thunder. During all this time the position of the cloud was unchanged. It hung there, a black dread, an unforgotten terror to all who saw it."

"When the two clouds had thoroughly compounded and become one, the deep black veil on the east side of the cloud dropped and exposed in its center of grey ash color a balloon shaped formation, with a tail or trunk extending downward below the cloud, while the bordering or main cloud was perfectly black. It appeared as some massive painting with a black backgronnd. To use his language, it was sublime but appalling. It then moved eastward acoss the Miami River, scooping the water from its bed and throwing it hundreds of yards. He says that its progress was not rapid, and describes the movement of the tail as that of an elephant's trunk reaching out, and from side to side grappling and devouring everything that was within its reach. After passing eastward, so that the westward side could be seen, it appeared as a black smooth wall, the grey balloon shape being entirely invisible, except that part of the tail which extended below the cloud. This was plainly visible for several miles. So dreadful was it in appearance, in noise, and the destruction of property, that the prayer of all who witnessed it is that they

may never see another. Its work of ruin is fearful, and its many strange and wonderful freaks are subjects for thought and investigation."

There is a striking uniformity in the descriptions of the meeting of two clouds in the formation of tornadoes.

Preliminary tornado-charts of all the late tornadoes are, we learn, in the lithographers' hands and will probably be distribuled by the time this meets the eyes of our readers.

THE WINDS AND CURRENTS OF THE EQUATORIAL ATLANTIC.

The examination of the equatorial regions possesses an interest that is attached to studies of districts which include the contact line of contrasted phenomena; and this interest is especially developed in the study of equatorial meteorology, for no where else does the atmosphere present a line of separation as sharp as that found along the meeting of the trades. As our ordinary wind-charts hardly do justice to the peculiarities of the equatorial belt, the accompanying diagrams of middle Atlantic winds and currents in opposite seasons may be of value. They are based chiefly on Toynbee's Nine 10° Squares,[1] which give with great detail the meteorological data about the Atlantic doldrums; the plain, two-barbed arrows show the winds and currents taken from this excellent monograph. For the Gulf of Guinea I have used Brito-Capello's monthly charts,[2] which in part lap over Toynbee's; double-barbed arrows with cross-bars come from this work. The one-barbed current arrows in the middle and western longitudes of the diagrams are taken from the British monthly current charts.[3] The one-barbed wind arrows west of longitude 40°, on the February-March diagram, are copied from the March sheet of the new charts of the North Atlantic just issued by our Hydrographic Office;[4] on the August-September diagram they are constructed from the British Pilot Charts for the Atlantic Ocean; the new series begun by the Hydrographic Office not having yet reached those months. The isotherms of air and water are based chiefly on Toynbee's charts, as results are there given for every two degrees of latitude; but they depend in part also on some of the other authorities above mentioned.

The shifting of the doldrums following the change in the sun's declination is the most striking feature exhibited in figures 2 and 3. This is shown in another form for the middle longitudes in figure 1, with the accompanying migrations of lowest barometer, highest air and sea temperatures, and most frequent (and presumably heaviest) rains, constructed from data in Toynbee's monograph. Here the dots with Roman numerals show the average latitude of these several phenomena within the three decades of longitude for every month; the shifting in longitude

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1 Monthly charts of meteorological data for the nine 10° squares of the Atlantic which lie between 20° N. and 10° S. lat., and extend from 10° to 40° W. long. London, 1876, with a volume of Remarks, No. 27 of the official publications of the British Meteorological Office.

2 The French translation of this Portuguese work is: Guide pour l'usage des cartes des vents et courants du Golfe de Guinee, par J. C. de Brito Capello; Paris, 1862. This is No. 342 of the publications of the Depot des cartes et plans de la marine francaise.

3 Currents and surface temperatures of the North Atlantic Ocean from the equator to latitude 40° N. for each month of the year, with a general current chart; London, 1872. These were constructed by R. Strachan, under the direction of R. H. Scott, chief of the British meteorological committee, and are the only monthly current charts of the North Atlantic yet published.

4 Meteorological Charts of the North Atlantic Ocean, 1883.

of the lines connecting the dots is merely for convenience of drawing. The placing of the dots cannot pretend to great accuracy, for in most cases the maxima or minima represented by them are not strongly pronounced. It is seen that the maximum temperature and minimum pressure have the greatest oscillations, and that their limiting or *tropical* latitudes agree closely; the sea-water maximum temperature and line of calms between the trades are also similar in their changes; the maximum of rains has the least shifting of all the set. The oblique medial line from latitudes about 1½° on the west to 4° on the east consequently marks the ocean belt that has most distinctly a double set of seasons in twelve months; or two years in one. The chief cause of the persistent preference of this belt for the northern hemisphere is undoubtedly the relative size, temperature and position of the equatorial currents as determined by the forms of the North and South Atlantic basins. The eastern side of the equatorial ocean, on which the cool currents will be felt, is closed to the smaller return current from the north, but wide open to the larger one from the south; consequently the line where the currents

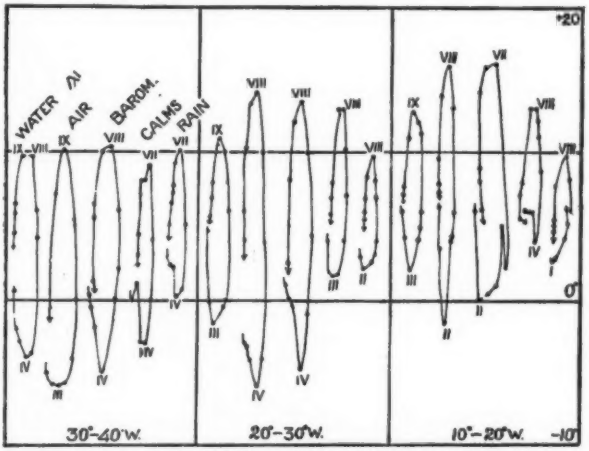

FIG. 1. THE METEOROLOGICAL TROPICS.

coalesce and the highest temperatures occur is carried north of the equator. The current from the south being the larger of the two, and being turned in greatest part to the north of Cape San Roque, the average stand of the heat-equator is north of the geographic equator all across the Atlantic. If the shore-lines were all inverted, and the current from the north had the more open entrance to the equator, we can hardly doubt that the line of highest sea-water temperature, with all its consequent effects, would be in the southern hemisphere. The attitude of the equatorial coast-lines, therefore, seems in this ocean to be more important than the general atmospheric circulation in determining the unsymmetrical attitude of the meteorological equator.

The trade-winds.—The conventional oblique blowing of the trade-winds to an equatorial line of meeting is seen to be most closely approached in the February months, west of 15° or 20° W. longitude (fig. 2). Farther east, the low pressures over the torrid lands of Africa draw the southeast trades into south winds; in other words, the general planetary winds are here strongly affected by a tendency

to a more local, continental circulation. The failure of the winds to turn more to the right, and blow from the southwest on the Congo coast, is doubtless due to the left-handed force coming from the earth's rotation. In the months opposite to February, when the oceanic belt of warmth and low pressure has shifted to the north, all the typical peculiarities of the East Indian periodic winds appear as the southeast trade crosses the equator into the northern hemisphere and becomes a southwest monsoon, between 15° and 35° W. longitude (fig. 3). The deflective effect of the earth's rotation has here a most admirable illustration, not only in the sharp right-handed turning towards the African coast of a large part of the southeast trade as it enters our hemisphere, but as well in the refusal of the northeast trade to turn in anything like equal volume, against its right-handed tendency, toward the Sahara.

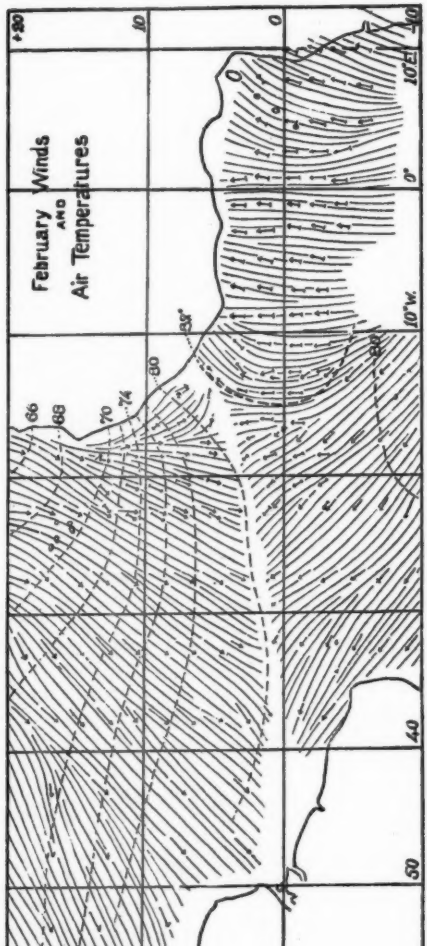

FIG. 2.

Overflow of the anti-trades.—Another point in theoretical meteorology finds clear confirmation in Toynbee's tables of the upper clouds. Discarding all those that were observed as moving with the surface winds, I have plotted the resultant (rather roughly constructed) of the remainder in figure 4. The wind-arrows here drawn are not placed precisely in their true latitude, but stand in their proper relation to the belt of calms; and in going from left to right in each 10° square one sees the observations of successive months, each of which should be on the middle longitude of its square. In spite of this somewhat free rendering of the observations, there seems to be nothing unfair in the method of plotting, so far as the present purpose is concerned. The harmonious result warrants this conclusion.

The overflow of the anti-trades north and southward from the calm-belt is distinctly shown. Moreover, the anti-trade of the northern hemisphere quickly swings around to the right from a SE–NW to a SW–NE course, because through most of the year it is far enough from the equator to be under the control of the earth's deflective force, which is proportional to the sine of the latitude. But the anti-trade of the southern hemisphere maintains its NE–SW course over several degrees of latitude, because through this distance it is near the equator where the deflective force is zero, and does not turn to the left and flow NW–SE until approaching the limit of the diagram, in latitude 5° to 7° south. The agreement of Mr. Ferrel's deductive results with the quick eastward turning of the anti-trades is very remarkable.

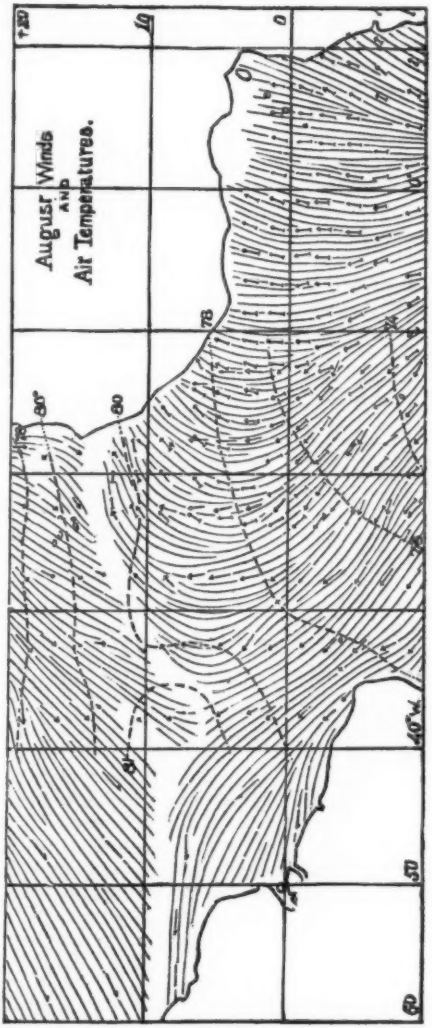

FIG. 8.

The equatorial ocean currents, although not within the limits of meteorology, are yet so closely connected with the winds that their illustration may be permitted in the remainder of this article. Figures 5 and 6 represent the equatorial currents of the Atlantic, constructed from the sources already named. The three currents—south equatorial, north equatorial and counter currents, with the continuation of the latter into the Gulf of Guinea—are separated, and the latter is clearly shown to be periodic in the greater or less westward extension of its narrow beginning. Toynbee's consecutive monthly charts amply confirm this. In the British Pilot Charts for the Atlantic (2d ed. 1875) the greatest westward extension is given at longitude 52° W.; more numerous observations are needed concerning the absolute limits, but of its periodic variation there can be no doubt. As ordi-

narily represented on current charts, an advocate of the wind as the origin of the ocean currents would have difficulty in explaining it. Herschel thought that the counter current of the Pacific might be caused by inequalities in the ocean floor,[1] but this would not serve here, for the Challenger map of the Atlantic gives no intimation of the existence of such shallows. Laughton[2] considers the counter current simply an eddy of the southequaorial current; but this explanation is not sufficient, for if true the latter surely should flow against Cape Palmas, which it fails to touch by one hundredmiles or more. Zöppritz[3] regards it as a backset, turned eastward between the north and south equatorial currents, as they flow against South America. This would not account for its periodic variation, or for the faintness of its beginning; nor is suffificient reason given to show why the two equatorial currents should leave an area between them not occupied by either one, when the trade-winds are continually brushing them together. The North Atlantic return current along the western coast of Africa is often drawn as sending forth a strong and persistent branch from the Cape Verde Islands down to the Gulf of Guinea;[4] but no detailed study of the currents warrants this. No such branch exists of significant size, and just when the counter current is most developed the branch from the North African current is least important. The distribution of water temperatures shows this distinctly, and shows further that the counter current cannot be fed by an ascending current from the bottom of the Atlantic. Krümmel,[5] who has described this part of the ocean in detail, seems to agree with nearly all these objections, but comes to an unconvincing conclusion. He considers the chief motive power of the ocean currents as a whole to be centrifugal force coming from the earth's rotation—an utterly inadmissable supposition on an earth of a uniform, not an accelerating, rotation—where centrifugal force is all consumed in combining with *gravitation* (the attraction of the earth), to produce the resultant *gravity*, at right-angles to which the level surface of the ocean would stand in steady equilibrium and without any currents whatever,

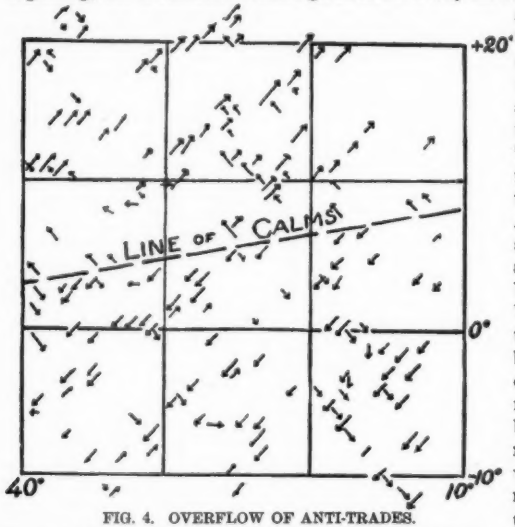

FIG. 4. OVERFLOW OF ANTI-TRADES.

1 Physical Geography, 1862, 57.

2 Physical Geography, London, 1873, 275.

3 Annalen der Hydrographie, vii, 1879, 155.

4 Among others, the Monthly Pilot Charts of the North Atlantic now issuing by our Hydrographic Office give this interpretation.

5 Die äquatorialen Meeresströmungen des atlantischen Oceans und das allgemeine System der Meerescirculation. Leipzig, 1877.

if no other forces acted upon it.[1] Further than this, Krümmel concludes that the Guinea current is due to some force not yet discovered; but this is little more satisfactory than his other conclusion.

Winds and Currents.—In 1705 Dampier wrote, in his Discourse on the Trade-winds,[2] "* * * the force of the wind constantly blowing one way, may, and probably does, move the surface of the water along with it." In 1872 Strachan wrote of the equatorial Atlantic, "The inference may, therefore, be drawn that the winds here rule the currents within certain limits."[3] These quotations and many writings of intermediate date lead us to what seems by far the most satisfactory explanation yet suggested for surface currents either in their general circulation or in their more detailed flowing.

The general winds cause the correspondingly general currents, and the adequacy of their action has been shown by Zöppritz.[4] Periodic winds cause periodic currents, as is strikingly shown in the reversal of the Asiatic currents from India around to China, with the change of the monsoons.[5]

Accidental storm winds cause a temporary deflection of even as strong a current as the gulf stream, as has been shown by Commander Bartlett recently.[6]

Hence, from beginning to end, the wind and current systems show precisely such agreements as might be expected between cause and effect, and there is no unfair exaggeration in Croll's emphatic statement: "So perfect is the agreement between the two systems, that, given the system of winds and the conformation of sea and land, the direction of all the currents of the ocean, or more properly the system of oceanic circulation, might be determined *a priori*."[7] Nowhere does this broad generalization find better support than in the counter current of the Atlantic.

Just in the season when the southwest monsoon is best established, the equatorial counter current attains its greatest development; and when the southward shifting of the wind-system prevents the passage of the southern winds far across the equator, the counter current is reduced to its smallest dimensions. The eastern extension of the counter current, known more especially as the Guinea current, is persistent with small change throughout the year; so is the eastward blowing of the winds over a moderate area west of Cape Palmas. We may therefore suppose that the return current from the South Atlantic is permanently displaced southward from this cape by the counter current that wedges in here from the west; and this entrance having been accomplished, the further flow of the Guinea current may be considered in part an eddy, or backset, required to fill the northeast corner of the gulf, which the South Atlantic current leaves to one side as an area of dead water. Even without the wedging counter current, an eddy would probably be produced in the gulf east of Cape Palmas, but in that case the South Atlantic current would certainly reach the cape, from which it is actually always driven off, as already mentioned.

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1 Centrifugal force may act, in a very faint way, to promote the deep drift of the ocean from poles towards equator, when the drift is begun by other forces. As the surface water in high latitude cools and sinks, it obliquely approaches the earth's axis, and consequently in accordance with the "conservation of areas" must tend to rotate faster than when at the surface. As a result of a shorter radius and a faster rotation (if it be attained), its centrifugal force will be unduly increased, and will tend to urge it toward the equator. This force has its maximum at lat. 45°, but it is even less than that arising from difference of temperature in the polar and equatorial oceans.

2 Voyages, ii, 103.

3 In the volume on Currents and Surface Temperature, above named, p. 26.

4 Hydrodynamische Probleme in Beziehung zur Theorie der Meeresströmungen. Ann. d. Phys. u. Chem., iii, 1878, 582.

5 See the British Admiralty Chart of Stream and Drift Currents in the Pacific, Atlantic and Indian Oceans, 1872.

6 Proceedings of U. S. Naval Institute, viii, 1882, 227, 228.

7 Climate and Time, Amer. Edit., 1875, 214.

Further objection to the eddy action is found in the very imperfect curling around of the eastern end of the Guinea current, where it should join the current that would produce the backset. It seems to come to an end about the islands in the gulf, as if it there turned downwards, and disappeared as an undercurrent; but this would hardly be expected, as Toynbee's averages show it, at least within the limit of his charts, to be a little less dense (on account of heavy rains) than the currents on either side; the average densities of the three currents, from north to south, being 1.0270, 1.0266, 1.0271. It is possible, however, that this relation does not hold good farther east, where the South Atlantic current has probably not yet been noticeably increased in density by equatorial evaporation.

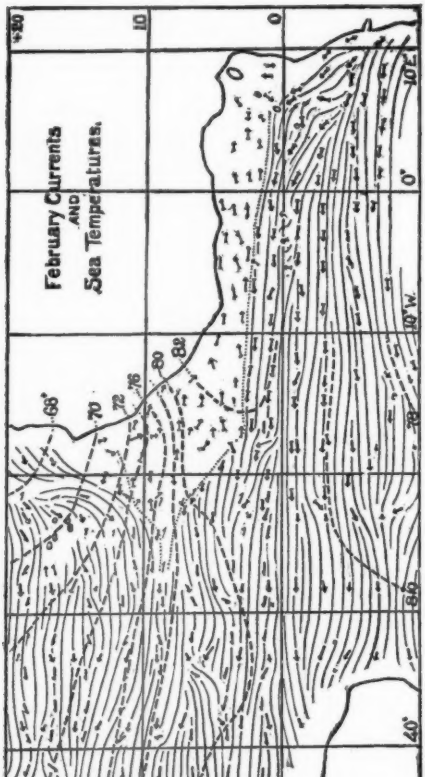

FIG. 5.

Deformation of the ocean's surface by winds.—The fact that the counter current does not always flow with the winds that blow over it does not seriously militate against the theory that it is caused by the action of the winds as a whole. Wherever a current flows against an obstacle in its path, it will depart from the direction of the local winds and take a course of least resistance between the action of the whole wind-system and the reaction of the oceanic basin; and at all such points of deflection, its surface must sensibly rise above the normal level surface. The divergence of the equatorial currents from the course of the winds north and south of Cape San Roque is a good example of this condition; another is found in the Gulf Stream proper as it issues from the gulf around the end of Florida in directions quite independent of the local winds; here its motion is due to momentum and gravity that carry

it down a slope that must exist between the Gulf of Mexico and the Atlantic along our coast. A deformation of the ocean surface from a level may be produced also along the line of meeting of currents that run towards each other; there each current acts to the other as the coast line did in the previous examples, and thus a flat mound of waters must be formed along the meeting of the trades in the February months. When the elevation thus caused is such that the down-slope component of gravity just equals the up-slope components of momentum derived from winds elsewhere, and of impulse from local winds, the mound will have a form of equilibrium; and the waters will move horizontally along its side in obedience to the lateral components of the moving forces. The westward motion of the equatorial currents may be thus in great part explained. In the August months, a similar mound may exist between the North African and the counter currents, each current moving horizontally along the side of the mound as just explained, and consequently here flowing in opposite directions. The surface of both the south equatorial and the Guinea current must rise toward Cape Palmas; and the opposite directions of flow here must be considered the effects of momentum elsewhere acquired and of the opposite impulses given by the lateral components of the local winds horizontally along the slope of the water surface.

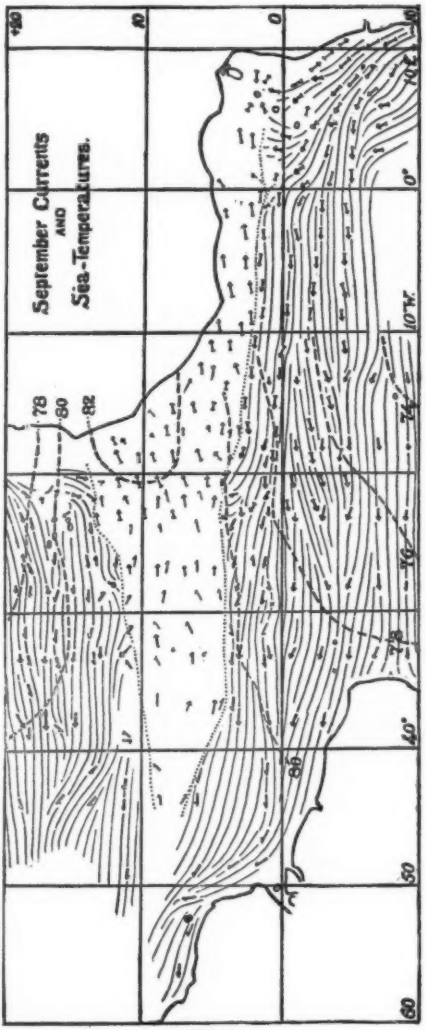

FIG. 6.

The Pacific counter current is not yet known well enough as to time and place to make a close description of its course possible, but it is marked as a persistent current a little north of the equator on the British current chart above referred to. The

monthly tables for the northeastern Pacific published by our Hydrographic office [1] show the occurrence of a monsoon-like extension of the southeast trade, appearing as a southerly or southwesterly wind about latitudes 5 to 10° N., east of longitude 115° W., in the late summer. It therefore seems plausible to suppose that the explanation here extended from Strachan's memoir will be found to have application in the Pacific ocean as well as the Atlantic, when the former is studied in sufficient detail.

CAMBRIDGE, MASS., April, 1884. W. M. DAVIS.

THE RAIN-FALL OF NEBRASKA.

Since the first settlement of this state, more or less interest has been felt in the amount of rain-fall.

This whole region was long thought to be too arid for cultivation; and when experience showed this opinion to be a mistake, the most common explanation was that the climate was changing, and the annual rain-fall increasing.

Some years ago, the writer undertook the task of collecting all the authentic records of rain-fall in the state, and it is proposed to give a summary account of them here, The entire records by years and months, are soon to be published in the Report of the State Board of Agriculture now in press.

The earliest authentic observations seem to have been made by the medical officer of the government post, Old Fort Kearney, in what is now Kearney County, and near the 99th, meridian. The mean rain-fall of the fourteen years, beginning with 1849, during which observations were taken here, was 25.22 inches; the greatest was 45.76 inches in 1849; the least 16.10 inches in 1859. During the same period observations were made at Bellevue, on the Missouri river, and near the mouth of the Platte, during 1858, '59 and '60. The mean of the three years here was 28.57; the greatest 50.92, in 1858; the least 16.21 in 1860.

So far as I can learn no records were made in the state during 1863.

In 1864, '65 and '66 records were again kept at Bellevue, in Sarpy Co. The mean of these three years was 20.21 inches; the greatest was 23.72, in 1866; the least 17.00, in 1864.

In 1866, observations were begun at Plattsmouth by Dr. Childs, and continued without interruption for fifteen years. The mean of this series was 38.07; the greatest was 55.85, in 1873; the least, 27.71, in 1880.

In 1868, two records were begun both of which have been kept up continuously to the present time. The eastern one is at DeSoto, in Washington county, on the Missouri river, and kept by Mr. Charles Seltz. The mean at this point for sixteen years from 1868 to 1883 inclusive, is 29.81; the greatest 43.83, in 1869; the least 19.29, in 1880.

The other record begun in 1868, was by the army sergeon at Fort McPherson, on the Platte, near the present site of North Platte, the county seat of Lincoln Co. In 1874, the observations were transferred to the U. S. Signal Station at North Platte, and have been kept there since. The sixteen years average here, is 19.16; the greatest 30.00, in 1883; the least 11.16, in 1876.

At the Santee Agency, in Knox Co. near the northeast part of the state, observations were taken by Mr. Geo. S. Truman, from May 1871 to the end of 1875. The mean here was 21.96; the greatest 27.39, in 1875; the least, 16.60, in 1872.

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1 Monthly charts of the North Pacific ocean from the equator to latitude 45° N, and from the American coast to the 180th Meridian, Washington, 1878. These were compiled under the direction of Lieut. J. A. Lyons.

The same observer gives us a record of four years, taken near Genoa, in Platte Co., supplemented and continued for four years longer by J. L. Truman, his son. The mean of this series of years is 25.66 inches; the greatest, 37.55, in 1876; the least 16.93, in 1879.

Col. Thomas Harbine, of Faribury in Jefferson Co. has kept a record of the rain-fall at that point since 1876, eight years. The mean of this series is 31.08 inches; the greatest, 37.55, in 1883; the least 23.04, in 1878.

At the Agricultural College Farm, two miles from the city of Lincoln, observations have been taken for nine years, beginning with 1875. The mean of this series is 30.47; the greatest 40.20; the least 21.41, in 1880.

A record was kept by Mr. C. Blodgett, at Howard, Nemaha Co. for six years beginning in 1875. The mean was 34.94; greatest 40.84, in 1877; least, 28.05, in 1875.

Of the records kept at Beaver Creek, Buffalo Co., by Mr. Erastus Smith, for six years beginning 1878, and still continued, the mean is 25.10; greatest 37.72, in 1881; least, 19.08, in 1878.

At Minden in Kearney Co., kept by Judge Hull, the mean of six years, is 34.33; greatest, 49.32, in 1879; the least, 29.25, in 1882.

Since the establishment of our volunteer weather service in 1878, a large number of persons have kept record of rain-fall for periods of two to four years, but there is not room to give them all here. What have been given, will serve for a fair sample of all.

Any one who will take the trouble to note these records carefully will find that they furnish a very slim foundation for any extensive generalizations as to increased or increasing rain-fall.

For the first half of the period covered by these records, observations were taken at only two points in the state, Kearney and Bellevue. Since that date, to compare with the older observations at these points, we have but a four years record at Kearney, and none at Bellevue. The first four years of the early observations at Fort Kearney (49–52) give a mean of 27.96 inches; the second four (53–56), give 27.68; the third four, (57–60) give 21.93, and the last four (1879–1882) give a mean of 28.24 inches. Comparing the last four with the mean of the fourteen earlier years shows a slight increase of rain-fall.

There are certain peculiarities of the rain-fall in this state worthy of notice:

The greater part of the rain falls in the six months beginning with April. For example, during the fourteen years of observation at Fort Kearney, while on an average 19.98 inches fell in the six months beginning with April, but 5.24 inches fell in the six months beginning with October. That is during the six months beginning with April about three-fourths of the entire rain-fall of the year occurs.

Again, a large proportion of the rain falls at night; this is especially true of the summer months. Perhaps four-fifths of the local thunder storms occur between 5 P. M. and 7 A. M. It is no uncommon occurrence to have a heavy rain with much thunder and lightning each night for three or four nights in succession, while the intervening days are clear, warm and dry.

The extremes of rain-fall given at the different stations, show that the amount of rain at a given place varies greatly, and sometimes in successive years. For example Bellevue had 59.92 inches in 1858, and but 18.57 inches in 1859. Nebraska City had 51.01 inches in 1869; and but 26.44 inches in 1870. The driest year since the settlement of the state was 1860, when but 16.21 inches fell at Bellevue, and 16.85, at Kearney, the only places where during that year records were kept.

Another peculiarity of our rain-fall is the great differences in amount at places near together.

For instance, in 1866, Plattsmouth had 36.14 inches of rain, while Bellevue six miles distant had but 23.72, both places being on the Missouri river. So in 1883 while Omaha had 47.91 inches, DeSoto, thirty miles distant and also on the Missouri, had but 15.47 inches.

Again the records show that unusually large annual amounts are nearly always swelled to uncommon proportions by one or two extraordinary rains.

For instance, May 1849, at Kearney, had 10.74 inches; July 1858, at Bellevue had 14.68 inches; at Plattsmonth 1873, 15.90 inches fell in April, and 19.00 inches in May; and in June 1874, 18.02 inches fell at the same place. In this last instance three-eighths of the entire rain-fall of the year came in this month.

Whatever may be the truth as regards increase of rain-fall, with the increased cultivation of the soil, there is reason to believe that with the larger amount of soil which is yearly brought into cultivation there is a certain amount of change in the climate in the direction of greater moisture. Cultivated soil will retain much more of the rain which falls on it, and this is gradually given off into the atmosphere through the foliage of growing crops, thus giving increased moisture to the air. It is possible that this circumstance alone will be sufficient to give a greater number of rainy days, a larger per cent. of cloudiness, and to modify the effect of hot winds. The observations taken by the State Volunteer Weather Service, if continued long enough, will enable us to answer this question with some degree of accuracy and confidence.

S. R. THOMPSON,
Director Nebraska Weather Service.

THE OAKVILLE TORNADOES.

The Tornado of April 1st, which passed through the northern portion of Henry and the southern parts of Delaware and Randolph counties, Indiana, was one of the most destructive that has occured in the state for years. It first struck the earth about three miles northeast of Middletown, Henry Co., though some damage had been done southwest of this point. From where it first descended to the earth it pursued a course a little north of east, leaving desolation in its path, and after entering Randolph county it again arose from the earth only to descend again and again as it passed through the county. Entering Ohio it passed near the cities of Greenville, Piqua and Troy, though judging from reports of the damage done the storm had spent its fury. East of these cities reports show that it occasionally caused more or less destruction of property throughout the state extending nearly to Pittsburg, Pa.

The day of the storm was one of variable temperature. It was cold enough in the morning to render overcoats comfortable, but as the day advanced it became sultry until about 4-30 p. m. when the storm-clouds commenced forming in the west and southwest. At this time it suddenly became much colder north of the tornado's path. Heavy banks of blackish green clouds, fringed with whiter ones, formed rapidly in the southwest and northwest and extended far to the northeast before the tornado-cloud began to take shape. So threatening was the storm approaching from the northwest that persons situated near the tornado's path saw no other angry clouds approaching until the terrible roar of the tornado warned them of the danger approaching them from the west-southwest. The storm from the northwest proved to be a severe hail storm which, advancing rapidly

toward the storm-centre, preceded the tornado. Throughout the day a heavy snow had been falling in Wisconsin and states to the northwest. Most persons near the path of the tornado saw angry clouds approaching from the southwest, west, and northwest which seemed to meet before the work of destruction began. Mr. M. D. Poole, who was teaching near the village of Oakville, saw two funnel shaped clouds approaching from the west and southwest which were rolling and

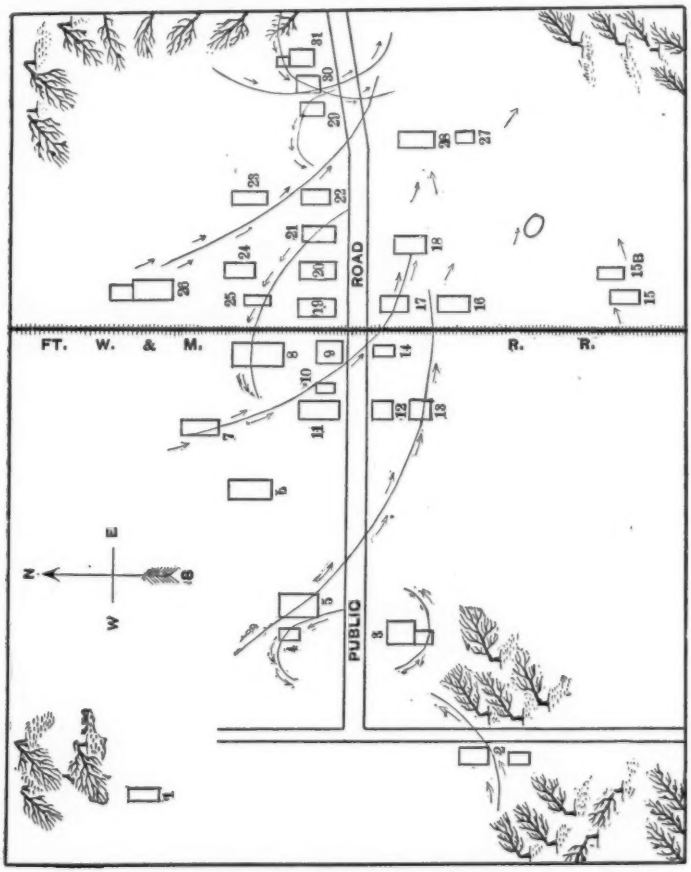

DIAGRAM OF THE OAKVILLE TORNADOES.

whirling contrary to the movements of the watch. Clouds seemed to sweep down on the right side only to rise with the ascending currents of the opposite sides. He sought refuge in a large building directly in the centre of the storm's path, usually a very imprudent thing to do, but perhaps fortunate in his case as the building was one of the few that escaped destruction. He did not see whether the funnels united before descending to the earth or striking the town.

One person who saw the two funnels described the south one as having its lower portion inclined to the south. It is probable that when first seen the funnel clouds were forming some miles away and had not yet begun their work of destruction. Mr. Driscrol who lives about four miles northeast of Oakville and two miles from the tornado's path saw only one funnel shaped cloud approaching. It seemed to be sweeping the earth as it passed to the south and east of his station. When the storm was directly south of him, the hail, which had been falling, ceased and he thought the storm over, but no sooner had it passed to the east than a heavy rain with a moderate wind set in.

Everywhere throughout the path of the tornado its work of destruction was manifest; buildings were torn down or unroofed; fences leveled to the ground and much valuable timber destroyed. Many trees were twisted off about 10 feet above the ground or split nearly their length. Every house south of the storm's centre but in its path, with one exception, was leveled to the ground so far as the writer's observations extended. Six persons were killed in Delaware county and many others injured. Fowls were killed and stripped of their feathers; nearly every thing was covered with mud especially the sides struck by the revolving currents of air. The persons killed, where not held fast in the debris of their houses, were carried from 10 to 50 rods to the east or southeast.

Southwest of Oakville the two funnel-clouds had not yet united, as trees lying with their tops to the northwest were seen in close proximity to others lying with their tops to the northeast; evidence of the close proximity of the right and left sides of the two storm-clouds. Still further south and north were seen the opposite sides of the storm's paths. One funnel was slightly in advance of the other as determined by the direction in which the rails of a north and south fence were thrown. A house and barn west of it were carried to the east-northeast while the fence was thrown to the west. This could not have been done except by the westward whirl of the south storm-cloud north of its centre. The house No. 2 of the diagram escaped this but was struck by the north storm south of its centre, the rotary movement carrying the debris to the northeast or rather north of east. The lighter portion however was carried to the orchard just east of the house and portions of it caught in the tops of the prostrate trees. The funnels must have united between this point and the east part of the village as there is no evidence of more than one tornado cloud east of the village.

House No. 3 was uninjured though the south wing, built of heavy timbers, was utterly demolished and thrown in a heap about 10 feet southeast of its foundation. The east and north sides of the house received a coating of mud. A small barn No. 4 situated almost directly north was torn to pieces and the debris carried to the northwest and southwest. A large barn No. 5 about 20 feet east of the latter was unroofed and the debris carried to the southeast. The distance between the buildings shows the progressive movement of the storm while the rotary currents were making one revolution and, as its path was ¼ mile wide, the velocity of its progression is to the velocity of the rotary currents as 20 is to the circumference of the circle produced by revolving currents. Although it is difficult to estimate the velocity of the currents within the storm cloud even approximately, it is easily shown, from the above to be many times greater than the progressive motion.

As the tornado struck the main portion of the village every building south of the public road was completely demolished except barn No. 15 B. which was unroofed. From house No. 12 two children were carried to the southeast 10 and 20 rods respectively and when found one was dead and the other had sustained a fracture of his skull. One person was killed in each of houses 17 and 15, while

from house 72 a young lady was killed and thrown 30 rods to the southeast nearly every vestige of her clothing being stripped from her body. House No. 6 escaped with the loss of a chimney while No. 7 was thrown in a heap southeast of its foundation. No. 11 was completely swept away the floor only being found in the street southeast of its foundation. No. 9, the largest building in the village, was struck from the northwest; the first shock was almost immediately followed by a second which tore away the roof and moved the building from its foundation 8 feet to the southeast. The mill, No. 8, was struck from the east or north of east, moved from its foundation and the tin roof and siding carried by the storm-cloud 2½ miles to the eastward. House 21 was unroofed and the rafters and other timbers driven through the side of house 20 which though still standing, is badly wrenched. Fortunately a number of families had taken refuge in the house 19 which escaped serious injury. House 26 was first struck by a current from the east which did no further damage than to cover the east and south sides with mud. Almost immediately after a current from the northwest carried away the north wing and out buildings; unroofed No. 24 and threw it on its side; lifted No. 22 and 23 from their foundations tore them to pieces and piled the debris in a heap to the southeast. Houses 29 and 30 were both demolished and carried as indicated by the arrows. House 31 was unharmed save the loss of a portion of the wing and some small outbuildings. This was fortunate as the inmates of the two houses to the west had taken refuge here although it was the smallest and weakest one of the three. Three cows were feeding at a straw stack near O; they were all killed and carried directly east, one about 10 rods the other about 30; one had both horns torn off.

After passing the town the storm veered to the south and before entering the timber evidently, for the first time within the observation of the writer, began to sweep the ground of its weeds &c. Entering the woods, the underbrush and tree-tops were filled with debris from the buildings, including furniture, bedding, clothing, cooking utensils, and articles from the store. Not all the trees in its path were prostrated but the majority of those with large tops were torn up by the roots or twisted off. A house ¼ mile east of Oakville was nearly in the centre of the storm's path and was torn to pieces over its inmates heads but fortunately injuring none of them seriously. One mile further east a new and strong house was swept away from its foundation while a small building, 3 or 4 rods to the northeast, that looked frail enough to be easily pushed over, was unharmed. From this point east the storm pursued nearly a direct course to the east line of the county, sweeping away houses and every thing movable in its course. East and west fences, south of the storm's centre were blown to the north; north of the centre, to the south; north and south fences, south of the centre, to the east; north of the centre, to the west.

The storm-cloud evidently did not sweep the earth over much of the portion of its path under consideration, for the rails in most cases were not carried over one rod from their foundation, and twigs, leaves, and other light articles were not disturbed both in the woods and open fields, except for a short distance east of Oakville. Persons who were in their houses when struck by the tornado say that the wind blew hard before the storm struck them and nearly every one was holding their doors. When the shock came the buildings quivered and then were lifted from their foundations, torn to pieces, and thrown in a heap. In some instances even the floors were moved from under the inmates' feet. Probably the suction of the currents within the storm-cloud was one of the greatest factors in the destruction of buildings, for when lifted from their foundations the power of the tor-

nado was not sufficient to carry them any great distance; nothing but light material being scattered along its path. The escape of house 3 and the destruction of its wing, house 6 being also uninjured; house 26 losing its north wing only; the houses 19, and 20, and 31 escaping, show that there are places within the storm's path, that are not subjected to the sweep of the powerful rotary currents. These facts indicate that within the vortex of the storm cloud, its whole area does not possess an equal power; that the whole area does not revolve around a centre with equal velocity, but that there are strong currents which traverse the vortex, whirling round and round its centre and which also partake of the forward motion. It is hardly probable that the rotary currents would follow the same path twice, even if the tornado did not advance.

We have seen that the side of the tornado south of its centre was most destructive, and, if the observations of Mr. Poole are reliable, the explanation is found in the downward sweep of the southerly currents, or in a reinforcement of the rotary currents by those descending, while north of the centre the tendency is upward as seen in the rising of the clouds on that side. Why should the descending currents be seen only on the south or right of the storm centre? The explanation will probably be found in the causes producing the tornado. We have seen that the day preceding the storm had been cold in the morning, in fact in the north and west a snow storm had been prevailing. As the day advanced the warm southwest winds had forced the cold currents to the north, or had taken possession of the battle-field of the elements.

This produced a rapid condensation of moisture to the north resulting in the formation of a hailstorm which about 5 p. m. advanced rapidly to the southeast, meeting the warm southwesterly winds. The cold air advancing from the northwest and west formed a barrier which the southwest winds could not force back, but were themselves crowded further and further to the south. This is seen in the course of the tornado,—first pursuing a northeasterly direction, then veering to the south and taking an almost direct easterly course. The warm currents, still striving for the mastery, could not move in any other direction except to the southeast or east as the colder air was crowding upon them, from both the northwest and west; consequently they would be forced to move towards the area of least resistance, the south and east. This would account for the rotary movement of the tornado being opposite to that of the hands of a watch. The southerly winds near the earth being unable to advance would rise and, to fill the space thus vacated, the air would rush in from all sides but most from the southwest or south, as well as from above, for at those points is found the greatest pressure. This movement once started would rapidly gain in velocity from the suction produced by the ascending currents.

If this view of the formation of the tornado be correct, the rotary movements are produced by the continual crowding of the southwesterly winds against the colder storm to the northwest, north, and east, and the tornado-cloud would be forced to follow the edge of the colder storm. That there are other factors which enter into the formation of the tornado, but which are not perfectly understood, is no doubt true, but in this case the prevalence of a cold area to the northwest and west, with strong currents of warmer air from the southwest, were the determining causes, whatever may have been the immediate factors entering into its formation.

The electric phenomena were not notable in this storm. Only two observers have reported them and in neither case was there a disruptive discharge.

All observers along the course of the tornado state that two storms seemed to

be approaching, one from the southwest, the other from the northwest, and that they *seemed* to meet before reaching their point of observation. The storms evidently did not unite, for they are represented as uniting throughout the entire path of the tornado. This, I believe, is the statement of nearly all who have observed the approach of a tornado; two storms always seeming to unite, but never uniting. Could this have taken place, the tornado would probably never have originated, for an equilibrium would have been produced. Oakville was evidently within the trough of lowest barometrical pressure, yet the Tornado Charts published by the Signal Service Department show that the greatest number occur outside of that area, either to the south or southeast, in the region of high thermometric contrasts. This being the case, the question arises, what influence has the presence of an area of low barometric pressure in the production of tornadoes? A study of the charts of the Signal Service show that around the area marked "Low" the winds are blowing from all points of the compass, or, in other words, that a cyclonic storm or condition of the atmosphere is prevailing which is likely to produce high contrasts in temperature, especially to the south and southeast. Heavy winds and thunder storms are of common occurrence while such a condition lasts, but tornadoes are not so frequent, as they can only occur where the conditions are favorable. High contrasts in temperature seems to be the most important factor in their production. No doubt, the rapid condensation of vapor is a potent agent, though it is the result of the thermometric contrasts where the atmosphere is saturated with moisture. It is probable that continued study and observation will show that the tornado is a storm due to local causes which are the result of the prevalence of a cyclonic storm.

MUNCIE, INDIANA. A. J. PHINNEY M. D.

THE DRY AND WET BULB THERMOMETERS "FRONDE."

A so-called thermometer "fronde" has been used in France for many years, and its use has gradually extended to other countries. It consists simply of an ordinary thermometer attached to a cord three feet or less in length. By swinging such a thermometer through a long circumference the temperature attained will be the exact temperature of the air, provided the result is not vitiated by friction, radiation, centrifugal action or other causes. Careful comparisons with a thermometer properly exposed have shown that the results are entirely reliable.

Some time ago the writer attempted to use this instrument as a wet bulb, and with such success that it was decided to fasten two thermometers together, the one a wet, with its bulb 1½ inches below the other which was dry. This arrangement has worked admirably, and has been in constant use the past winter in determining temperature and humidity conditions at a large number of points in city and country, in courts and rooms. Every one who has undertaken humidity observations with a wet bulb thermometer, and who has been annoyed in calm cold weather by its sluggishness of action, it often requiring more than an hour's delay, will recognize the importance of this plan. With this instrument there is no difficulty in obtaining a correct result in about two minutes, and, what is more important, the same result may be had again and again rewetting after each observation.

It will be seen that the instrument is an important means, for ascertaining proper localities for the exposure of thermometers in any region, for all travelling parties who wish to make observations of temperature and humidity, and for all stations where the temperature is below freezing.

A very interesting investigation has also been undertaken with the apparatus. It was found that with an air temperature several degrees above freezing and the wet bulb reading several degrees below, the latter could be brought to a stationary point without being frozen, as is well known, the moment of freezing is always clearly shown, by a sudden rise in temperature to 32°, where it remains for a short time before it begins to fall with the wet covered with ice. Having brought the wet covered with water to a stationary reading, a few moments afterward it freezes, and by continued swinging the frozen bulb could be brought a second time to a stationary reading and thus comparisons be had between the bulb covered with water and with ice. Theory indicates that the formula for determining the relative humidity from a wet bulb covered with ice should differ from the one to be used in case the bulb is covered with water. Repeated experiments seemed to show that the more correct results were always to be obtained with the formula for water, whether the bulb had ice or water upon it.

These results were vitiated, however, by the fact that the humidity changed between the two observations, and because it was impossible to secure absolutely the same conditions at both times. It was found necessary to place three thermometers side by side, the dry in the middle, with its bulb 1½ inches above the wet bulbs on either side. Each observation was made as follows: the instrument was first carried into the open air and a coat of ice was formed upon one of the wet bulbs by dipping in water and freezing it; the instrument was then carried into a room where the wet bulb temperature was below freezing and the dry above. After swinging until the ice covered bulb gave nearly a stationary reading, the other wet bulb was wet and the whole apparatus was swung until all the temperatures had become stationary. This, then, gave one wet bulb covered with ice and the other with water at the same moment, and hence allowed of a direct comparison. The following table gives some of these observations. Corrections have been applied to all the thermometers, but in order to check the whole work two sets of readings were made the first 10 with the left hand bulb covered with water and the second 5 with the same covered with ice.

Readings of thermometers as dry and with ice and water:

Number of thermometer:	101	135	434	101	135	434
	Water.	Dry.	Ice.	Ice.	Dry.	Water.
1	27.4	33.1	27.4	30.3	39.1	30.4
2	27.5	33.3	27.4	29.5	37.6	29.3
3	28.1	33.5	27.8	30.0	38.0	29.8
4	28.2	33.6	28.0	27.1	34.9	27.1
5	29.0	35.9	29.0	29.2	37.5	29.4
6	28.6	35.4	28.7			
7	28.4	34.2	28.3			
8	27.9	33.4	27.8			
9	27.4	33.4	27.4			
10	27.8	33.1	27.8			
Mean	28.03	33.89	27.96	29.22	37.42	29.20

The means of these observations give by Regnault's formulæ the following relative humidities:

	1st series.	2d series.
Wet bulb covered with water.....formula for water.	39.3 per cent.	30.4 per cent.
" " " ice..... " " ice.	43.6 "	33.6 "
" " " " ..... " " water.	3.88 "	30.6 "

These results show satisfactorily that the readings of a wet bulb, if covered with water, do not differ materially from reading when covered with ice, and that the formula for water alone will always give the better result.

We may conclude, then, that in the practical use of the wet bulb thermometer for obtaining the humidity of the air there should be no change, or only a minute one, allowed for, in the law, in going from water to ice.

WASHINGTON, D. C., Apr. 4, 1884. H. A. HAZEN.

THE ARCHED SQUALLS OF THE INDIAN OCEAN.

(Letter from M. Millot to M. Le Goarant de Tromelin, presented by M. Faye.*)

"These *trombes* between clouds in the form of funnels or of anvils observed for the first time in the Pyrenees by Commandante Rozet, are frequent in the zone of equatorial calms. They generally surmount the local squalls of these latitudes. When you pass that way, think to observe this phenomenon: you will see that the squalls which are visible at the horizon all around the ship are surmounted by a vast white anvil dominating the black cumuli, and these the curtain of rain.

It would be easy, if we could be present at the formation of one of these anvils, to solve once for all (and very certainly in favor of the theory of M. Faye) the question, always so disputed, of ascending or descending *trombes*.

In case you do not intend to cross the line soon, recommend this observation to a trusty colleague—I mean by that, one without preconceived ideas on the subject.

I always neglected to make this observation in passing the line (if youth only knew!); but as I sketched and observed much, I remember very distinctly the characteristic figures of the points which surround the horizon in the equatorial calms.

When they strike, they empty torrents of water, and the breeze turns more quickly than the sails can be trimmed, which (by parenthesis) attracts to you the unmerited remonstrance of the commandant. Before, as after, the squall absolute calm.

There, I think, are the characteristics of a *trombe*, coming from the upper regions toward the lower layers of clouds; and they are only the result of cold occasioned by the irruption of the upper air.

I should like your opinion of the arched squalls; I described them in my paper, as I have always observed them, guarding myself well from hazarding the least explanation; I have none which satisfies me.

I said that they seemed of themselves to enclose thunder bolts in their bosom, because that is the appearance, but I regret having given that turn to the phrase. It might be believed that I am of the opinion that they are themselves a source of electricity, while I have no doubt that they draw it from the upper regions to conduct it to the earth. Without that, the common reservoir would quickly have absorbed their provision, unless we compare them with accumulators, but that would become fanciful.

It is of this form, in an arch, that I found no satisfactory explanation. It is not an effect of perspective: the ends touch the ground; they have the violence of a *trombe;* the middle of the arch acts like a common squall.

They are frequent in the straits of Malacca, at the change of the monsoons."

M. Faye having presented the preceding note, adds the following remarks.

"It seems to me that the singular form of these arched squalls is explained naturally by the joining of two ordinary squalls, forming two *trombes*, widely separated below, but uniting above by their funnels. This joining has been observed several times. We find a memorable example of it in the double tornado which passed through and ravaged France in 1788 in two parallel paths.

If in France the sky had been that of the tropics, if the phenomenon had taken place in the day-time instead of in the night, these two tornadoes, joined above but of which the ends were separated by a distance of 5 or 6 miles and even more, would certainly have presented nearly the appearance of the arched squall. There

*Translated from *Comptes rendus* No. 6.

exist, nevertheless, certain differences of appearance between these double tornadoes and the arched squalls, which have prevented M. Millot from accepting this explanation. But if it is true that all the storm phenomena originate in whirling movement descending from the upper regions of the air, we will be led to attribute to purely local circumstances the differences in question and to retain as true the foundation of the preceding explanation."

NEW VIEWS ON THE CONSTRUCTION OF ANEROID BAROMETERS AND MANOMETERS.*

Some time ago, the Commission for Standard Weights and Measures in Berlin interested itself in trying to find a barometer or manometer for the determination of the pressure in the receivers of their vacuum-scales, in which the use of mercury could be avoided. This was considered desirable because it had been found that at ordinary temperatures the tension of the vapor of mercury was so appreciable as to cause a preceptible error in the determination of pressure by columns of this liquid. Only aneroids could be considered and it was doubtful if, on account of the well-known inadequacy of this instrument to give the accuracy required, a satisfactory result could be obtained even from a whole series of the manometers, though they had been previously compared with a good standard mercurial barometer. The accuracy demanded in fine measurements of weight is very great. That now attainable in comparative weighing of a kilogram of quartz with one of platinum is $\pm 0.01^{mg}$ and this requires an accuracy of $\pm 0.02^{mm}$ in the determination of the air pressure. This is an accuracy which can be attained by the best mercurial barometers only by the greatest circumspection in observation and most laborious reductions with use of the theory of errors. A precision of $\pm 0.1^{mm}$ has been considered sufficient in aneroids, and, with this, the index-error was left to be obtained by comparison with the mercurial barometer and changes due to temperature were entirely neglected.

The investigations attempted by the Commission, for the purpose above indicated, were intrusted to the best makers but led to no favorable results, and I decided to busy myself with the causes of the inefficiency of the aneroid. Meantime the results of the investigation have lost their direct interest to the Commission, as it has been discovered by Ernst B. Hagen and by Hertz that at ordinary temperatures the tension of mercurial vapor may be considered infinitesimal. Nevertheless, I think there is a general interest in the subject; hence I communicate the results to which I arrived.

In inspecting the ordinary aneroid, the most striking feature is the remarkably small amount of motion in the vacuum-box. I found it to be in the most perfect instruments, at the most, only 0.01^{mm} for each millimeter of the mercury column; in the most of the instruments it was far below this and in some it was less than 0.001^{mm}. This small motion in the box requires, for accurate observation, very great mechanical or optical enlargement, which of itself introduces many, and sometimes large, errors. Indeed, when the motion is less than 0.001^{mm}, while it is required to accurately observe fractions of this magnitude, the requirement of accurate observation may be considered unattainable. That, in this state of the case, the aneroid is as efficient as it is found to be, shows the care employed in its construction and is much to the credit of the manufacturers. The perfection of Naudet's mechanical

*Translated from the *Zeitschrift fur Instrumentenkunde*, Vol. III. pp. 89-95.

transfer appears to me, from this point of view, worthy of the highest admiration. As is well known, the elasticity of the box could be made to give, under favorable circumstances, twenty times as much motion as is found in the best aneroids. A round corrugated sheet of metal 10^{cm} in diameter, can be bent either way a distance of 3^{mm} without danger of permanent change of form. By putting two such sheets together to make a box the entire motion from most concave to most convex would be 12^{mm}. If the measurable variation of pressure is very small, as in a stationary barometer when the distance need not be more than 60^{mm}, it would be possible, if the entire motion of the box could be made available for this interval, to have each millimeter of the mercurial column correspond to 0.2^{mm} in motion of the box. This is a magnitude twenty times as great as the maximum motion above mentioned, and is large enough to make it possible to measure its tenth-parts, as is required by the Commission.

The cause of the smallness of the motion of the box in ordinary aneroids is found in the unusual strength of the spring required to enable the box to support the pressure of the atmosphere. In stationary barometers the spring must support a pressure of from 30 to over $50^{k\varepsilon}$; the small changes in this load produced by variations of pressure are not strong enough to deform the heavily loaded box. A round plate uniformly loaded and supported at its center and edges—the case with the aneroids—will, as can be easily shown, have $\frac{1}{4}$ of its load on the circumference and $\frac{1}{4}$ on the middle. A box of two plates has on its spring a pressure of

$$2\times\tfrac{1}{4}\times 1.03\times\frac{\pi d^2}{4}=0.5394d^2$$

in kilograms. In this, $1.03^{k\varepsilon}$ is the pressure at 760^{mm} of the mercury column on each square centimeter; π is the ratio of the diameter of the circle to the circumference, and d the diameter of the box in centimeters. In our Illustration, if $d=10$, the spring would have to carry a pressure of $54^{k\varepsilon}$ in round numbers. But the change of pressure by a variation in the mercury column of $\pm 30^{mm}$ would be but about $\pm 4\%$ of the above magnitude or $2.16^{k\varepsilon}$. Assuming that the box is held by the spring in its mean place by a mean pressure of 760^{mm}, the addition of $2.16^{k\varepsilon}$, representing the greatest pressure, must press in the spring 6^{mm} in order to move each plate 3^{mm}. An additional difficulty is found in the fact that the resistance of the spring increases with increased bending. When the pressure of the air decreases, in which case the spring expands the box, the force of the spring decreases with the decreasing demand on it, while for these purposes exactly the opposite is desirable. The property of the spring of giving a greater resistance to increasing, a less to decreasing, demand on it, is in this case as unfavorable as possible. From this standpoint we may designate as an improvement, the employment, made lately by W. Lambrecht of Göttingen, of suspended weights in the place of springs. They, at least, have uniform action.

The strong springs of the aneroids have another source of error, and that is the great tendency to alterations in their elasticity, to which they are subject, notwithstanding the care exercised in the material employed. The weight is superior in this respect. Finally the great demands make on the knife-edge suspension of the spring are bad, in that its increasing blunting introduces error, aside from the inaccuracies produced by irregularities of form which must occur unless the greatest care is used in the construction.

From the above it would seem desirable to omit the spring and give the corrugated plates enough strength to enable them alone to carry the pressure. This was tried for a time in Goldschmidt's aneroids, but it does not seem to have been preserved, and lately it has been tried by J. D. Möller in Wedel, Holstein. It is

evident that it makes no difference whether the box alone acts or a spring is put in, as in either case the action is of the nature of a spring. It seems to me that the latter is better, since in bending the spring a suitable form can be adapted, while no other advantage can be got from the former than a less load on the suspension-edge or its entire omission.

In this state of the case it seemed to me desirable to find some means of relieving the box of its load so far as possible, without changing the elasticity of the corrugated plates. For this purpose we must find some means of relieving the surface of part of the pressure.

Imagine two vacuum-boxes of unequal size fastened to the same plate at some distance from each other, erect between them a balance, the support of which is fastened to the plate and the ends of the beam each to one of the boxes. Then the deformation of this system will depend only on the surplus of the motions in one box over that of the other, since in so far as the pressure bends the plates of one in, the beam pulls the plates of the other out. If the difference between the plates is not large, a spring can be dispensed with though it might be desirable to relieve the beam somewhat of its load by that means. The same arrangement could be used for two equal boxes if the balance-arms were unequal.

We can dispense with the balance and put the two boxes together into a double box. Imagine that each one of the plates of a vacuum-box is made of two, unequal in size, their centres connected by a short metal rod. Let them be set in a proper ring and the air removed from the chamber between them. In the aneroid thus made the deformation, as in the previous case, is due to the surplus of the pressure on one plate over that on the other. The remaining pressure expends itself on the interior and is harmless. If a compound box is made by putting together the double plates above described, and air is admitted to the space between the two pairs, a loaded double box is obtained of the same deformative capacity as the two component boxes without springs. The action is the same as if inside a larger box was set a smaller one into which the air was admitted while excluded from the space between the two. The two boxes work against each other, and the resulting deformation is that due to the difference of the pressures on the two boxes. This difference can be made as small as we please, so that a spring may be dispensed with or made as weak as desired.

Thus can be avoided the objections to the spring, but no advantage is yet gained in increased deformation of the box. In the same ratio as we relieve the box of pressure, we decrease the deformation, and the result is the same as that which is obtained by making the plates so strong that no spring is needed. If we can replace the spring by some arrangement, such that its resistance rapidly decreases as the pressure increases and the plates are bent in, and as rapidly increases when the pressure falls off and the plates return toward parallelism, we will have overcome this difficulty. Such an arrangement is found in the leaving balance, when an inclined lever is loaded at one end. This can be replaced, for portable instruments, by a spring, but this is not objectionable, as the spring need not be strong. I now proceed to describe a stationary barometer with these novelties, so far as, after what has preceded, a description is necessary. It is provided with a weight, the use of which is admissible for stationary instruments.

The vacuum-box is double, constructed in accordance with what precedes, and the difference in size of the corrugated plates is such that the highest observable pressure of the air (790^{mm}) deforms each plate 3^{mm}, and the whole box 6^{mm}. The force necessary is not so small as might be expected. It amounts on a box of

10^{cm} diameter—the only one unfortunately, available for my experiments, the elasticity of which, by the way, I could test only by setting weights on the center and supporting the edge; unsymmetrical bending, and even cracks, could not be avoided—to about 400^{g} per millimeter. This number is, of course, too uncertain to serve as measure for the surface-difference in construction. Manufacturers can easily get for themselves a more accurate determination for the corrugated plate they propose to use. The two independent halves of the compound box are screwed into a cylindrical ring which is provided with orifices for free passage of air into the space between them. The compound box is then suspended on two knife-edges, of which the lower is fastened to the frame while the upper is connected with the short arm of a lever. The long arm of the lever is inclined to the short at an angle of 120°, and the length of the shorter one is so chosen that with a deformation of 12^{mm} in the box, the long arm moves through 60°. At the further end of the long arm of the lever is a cylindrical weight. This arm should stand vertically when the pressure is greatest (790^{mm}); the entire pressure is then exerted in deforming the box. As the pressure diminishes, the tension of the box decreases, but this decrease is too slight in a stationary barometer to produce perceptible changes in form. As, however, the lever lowers with rapidly increasing momentum, it aids to the utmost the endeavor of the box to take on its mean position, so that with this mean pressure (760^{mm}) the mean position is already approximately reached; at lowest pressure (730^{mm}) the weight suffices to draw the plates some 6^{mm} beyond the mean position. From these considerations can be determined the size of the weight and the most favorable angle for the lever. Perhaps the latter should be greater than 120°, since, for a certain size of the weight, unstable equilibrium comes in, that is, reversal of the entire system at the end position of the arm—and this can be connected only by an increase of the angle on which follows change in the length of the arms. Nothing more definite can be said on this, as it depends chiefly on the elasticity of the box, yet, in the worst event, it would only prevent the use of the entire deformative power of the box, yet enough would remain over to show the superiority of this method of loading over the usual one. Besides the objection in question decreases in proportion as the range of pressure to be observed is increased, and this must occur in the most important of these instruments, viz, in travellers' barometers and in orometers.

At the end of its path the weight is provided with a support. A circular spirit-level provides for its horizontality with sufficient precision. The weight carries a divided arc which is inspected by a lens and gives the required accuracy in reading. The arc is divided from 730 to 790 and the desirability of large motion in the box, giving a large arc, if evident. For portable instruments the weight is to be replaced by a spring—best a spiral spring—which must be hung between knife-edges. In that case, the maker must take care to have the force always go through the point of suspension, and it would be well to have a shorter arm, in order to avoid excessive changes in the form of the spring.

The requirement to increase the proper motion of the box as much as possible, and at the same time to dispense with the powerful spring and its overworked suspension, seems to have been solved, in a way, in what precedes. But I am far from believing that the proposed improvements must be used to their extreme limit in order to overcome most safely the known and lamentable deficiencies of the aneroid as at present known. On the contrary, it is possible that with the great deformations of the box here required, there will prove to be injurious elastic effects which may be as objectionable as the spring, and that, consequently, usefulness of this idea is limited. Yet, if the amount of deformation must not surpass

that employed at present, yet a great gain is made in dispensing with the spring and its overloaded suspension, since the gain in delicacy and mobility must prove serviceable.

It should also be noted that the common Bourdon-aneroid is, properly speaking, a box eased of its load by the above principles. But it would not be right to reject the principle because Bourdon's aneroid has been almost entirely replaced by corrugated-box aneroids. The motion of the Bourdon-spring depend on such an extremely small difference in surfaces and consequently on so little motive power, that the smallest elastic irregularity or the least resistance in the transfer mechanism must alter its stand. This disproportion does not exist in my system.

It would please me if the manufacturers would decide to undertake an investigation in the line of the preceding suggestions in order to ascertain to what extent this important species of instrument is perfectible, and would publish their results. If they will give me the necessary data on the elasticity of the boxes to be used, I should be pleased to give them every possible aid in the construction.

DR. G. SCHWIRKUS,
Technical Assistant to the Imperial Commission
on Standard Weights and Measures at Berlin.

SCOTT'S METEOROLOGY.

(Elementary Meteorology, by Robert H. Scott, London, Kegan Paul, French & Co., 1883. 8vo. 408 p. International Scientific Series, xlvi.)

Mr. R. H. Scott, secretary of the Meteorological Council of the Royal Society, has evidently felt, in company with most of our modern meteorologists, the lack of a satisfactory manual on meteorology, for in his preface he states that he has been induced to compile a text book in response to frequent applications for a work on the subject that could be recommended. We may therefore suppose that he has found Buchan's books in some respects insufficient, and we might expect that he would consequently prepare a volume in which more attention should be given to dynamical and deductive meteorology. But while his book contains many improvements on Buchan's, it is still essentially characteristic of the English statistical school of meteorology; and it is with regret that one finds certain questions treated insufficiently or inaccurately, and that one fails to find others treated at all.

Yet on the whole the book makes a good impression. The arrangement is satisfactory, and the number and variety of examples and illustrations suffice for the average student. A brief introduction treats of general matters, then follow chapters on atmospheric physics (temperature, radiation, pressure, moisture) and phenomena (dew and clouds, rain and snow, wind, electric and optical questions); and in a second part come the geographic subjects, such as distribution of temperature and pressure, winds, sea currents and temperatures, rain, climate, weather and storms. There are world charts, giving isotherms, isabnormals, isobars and winds, sea currents and temperatures, and lines of equal annual variation of temperature (Supan's *Isotalantosen*); and a good index.

It is especially with relation to the temperature of the air that we feel dissatisfied. The subject is not treated with desirable accuracy. The mention of insolation does not approach the admirable discussion of this question in Hann's *Klimatologie*, and under radiation there are several objectionable forms of expression. It is said that "water is heated with great difficulty, and gives up the heat, which

it has once acquired, with equal reluctance" (p. 46). Evidently there is confusion here between heat and temperature: water is not reluctant to radiate its heat, but a good measure of heat must be radiated before its temperature falls significantly. A similar error is seen in the peculiar statement "that it is very difficult to heat up the sea surface, but that when once it is heated it retains its temperature and does not materially warm the air lying above it, while the contrary is the case with dry land" (p. 220). Again, it is written that "the facility with which heat is radiated from the earth into space is affected to a great extent by the nature of the covering with which the earth is provided; grass and herbage are better radiators than earth or gravel" (p. 60); and straw is mentioned as a "powerful radiator" (p. 62; see also p. 118). The most natural inference that a student would draw from these ill-advised expressions is that grass and herbage and straw radiate a *greater amount* of heat than do earth and gravel: but this is by no means the case. They *cool* more, to be sure, but only because the amount of heat that they lose is not made good by conduction. The common statement, "poor conductors are good radiators," involves the same confusion of ideas as that met in the above quotation.

On p. 213, it is stated that the vertical decrease of temperature in the atmosphere is 1° in 300 feet instead of 1° in 180 feet because of the liberation of latent heat from condensing vapor; but no mention is here made of the imperfect diathermance of the air, as a cause that acts powerfully to the same end. On p. 137, three causes of rain are mentioned. "1. The ascent of a current of damp air into the colder regions of the atmosphere. 2. The contact of warm and damp air with the colder surface of the ground. 3. The mixture of masses of hot and cold air." Now one who reads this for information will almost unavoidably infer that the cold of the first cause is something inherent in the upper regions; he would hardly understand that it came from the expansion of the rising air itself. On p. 138, there is brief mention of the cooling of ascending air, but no mention of its cause in expansion; and the rate of cooling, 1° for 182 feet, is in one line given for air from which no moisture is condensed, and in the next (and again on p. 288) for "perfectly dry air." In addition to this inaccuracy concerning fact, there is a want of adequate explanation of the ascent of the air, by which the cooling is produced. The second named cause of rain follows a common misapprehension on the subject. It is not by contact with the cold land-surfaces of winter time that the air which blows over them is chilled, but by the failure of the land to give out radiant heat in quantity sufficient to maintain the temperature that the air has gained over the sea. Similarly, only half the truth is told on p. 123, when the cold of mountains is said to cause the formation of clouds in the air that rises to pass over them. The third cause of rain is justly estimated as of small value; but a fourth cause of importance is omitted; namely, the cooling that is allowed as winds move poleward to latitudes where insolation is decreased while radiation goes on unchanged: a very effective cause in middle latitudes.

The action of latent heat of condensing vapor finds no mention under the description of the föhn, nor is it considered in the brief chapter on storms, although its perception constitutes one of the most striking advances made in physical meteorology. The formula for the deflective force arising from the earth's rotation is given with only half its value (p. 245); but the regret over so trivial a mistake is far outweighed by the satisfaction that one must feel on finding at last an English text-book in which it is admitted that the direction of a wind has nothing to do with its deflection. This is vastly better than Buchan's and Ley's error and Laughton's denial. Blanford's precision, in his exellent *Vade-mecum*, need

hardly be considered an exception to the generally incorrect English usage, for in India he is so far away from home as practically to be excluded from the English school. And yet Scott's appreciation of the deflective force goes but a short way, for it is said that no satisfactory cause has yet been found for the exceptionally low pressure of high southern latitudes (p. 250). Under hail-stones, the author writes that no sufficient explanation has yet been offered of the agency which enables them to remain suspended for a time in the atmosphere (p. 145); and while Volta's and Dove's exploded theories find mention, no place is allowed to the theory that connects hail-storms with violent uprushes of unstable air. Indeed, the vertical equilibrium of the atmosphere is nowhere discussed, although a good statement is made of Hann's explanation of the general atmospheric circulation as dependent on the slope of isobaric surfaces.

In spite of all these criticisms, the book is not to be condemned. It is in general clearly stated, and is well written and readable throughout. A bad book can be briefly characterized and dismissed, but a good one is worth close examination, even to the extent of pointing out its faults, and setting up signs marked 'dangerous' on some of its pages.

We hope it may be republished in this country as a volume of the International Scientific Series.

W. M. D.

THE U. S. Coast Survey has recently issued a map of Alaska on a scale of 40 miles to the inch. It is compiled by Assistant W. H. Dall, and includes all accessible data down to Oct., 1883. The map is in colors, the execution is good, and the results attractive in appearance. The changes on Mr. Dall's map of 1869 are numerous, and indicate the advance which has been made in our knowledge of the Territory in the 15 years which have elapsed since then. There are many minor additions and changes of orthography, nomenclature and position. The changes which are greatest and of most general interest are those in the Upper Yukon River resulting from Lieut. Schwatka's journey and the new Meade River, near Point Barrow, due to Lieut. Ray. The latter stream does not seem to have the length which its reported width would justify—due undoubtedly to the level character of the country and slow velocity of the current. Mt. St. Elias rises to 19,500 feet, 5,000 feet higher than given in the old map. There are besides many local changes about Cape Rumiantzoff due to Nelson, on the Arctic Coast of Siberia due to Hooper and others, and on the western part of Aliaska peninsula and Alexander archipelago due to the Coast Survey. Mr. Dall's services to geography in adding to our knowledge of Alaska have already been very great and the compilation of this map adds materially to them.

AMERICAN METEOROLOGICAL JOURNAL.

AN ILLUSTRATED MONTHLY

DEVOTED TO SCIENTIFIC METEOROLOGY AND ALLIED BRANCHES OF STUDY.

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—EDITED BY—

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LITERARY NOTES.

—The Nebraska Weather Service in the bulletin for April has reports from 36 stations.

—The Michigan State Board of Health issues a weekly statement of diseases in Michigan and summary of the meteorological elements at Lansing.

—The Massachusetts State Board of Health, Lunacy and Charity publishes with its weekly return of mortality a statement of the weather for the week in Boston.

—The *Monthly Weather Review* for February gives the authentic facts and figures for the Ohio River flood. The highest point reached at Cincinnati was 70 feet and ¾ inch, which is 20 feet above the danger line. From Cincinnati southward the Ohio reached the highest level ever recorded.

—Considerable discussion is now going on concerning proper thermometer exposure. The principal contributions have been that of Professor Mendenhall in a number of *Science* some weeks ago and that of Dr. Hazen in the May number of the *American Journal of Science.*

—The *Pilot Chart of the North Atlantic Ocean*, issued by the U. S. Hydrographic Office, for May shows an unusually large amount of floating ice for April extending from 40° to 60° W. longitude and nearly reaching latitude 40°. A solitary waterspout is recorded; this time for April 8 and directly off Cape Hatteras.

—*The Ancient Merrimack in Aphelion Winter*, by Samuel D. Lord, is a study of the glacier period in the Merrimack Valley. It is cast in popular form and is published as a pamphlet of 19 pages for the New Hampshire Board of Agriculture. Mr. Lord accepts the studies of Croll and thinks that the mean winter temperature in the glacier period in New Hampshire must have fallen at least to 3° below zero.

—*Professional Paper No. VII* of the Signal Service has been revised and reprinted. The changes are slight. A brief list of the sources of information is given, but there are no indications, for the individual storms in the list, as to where they can be found and the tabular statements verified. In most of the later

cases the data are doubtless derived from correspondence, but in the older ones, and in not a few of the newer ones, published accounts exist; and a reference to these with volume and page, as an additional column in the table, would add largely to its scientific value.

—Mr. F. R. Weidner, in a recent account of the State of Sinaloa, Mexico, published in *Petermann's Mitteilungen*, No. I, gives an instructive account of its climate. Among other, and not unfamiliar, details he mentions a violent storm called *Cordonazo de San Francisco* which sometimes comes on in October when the southwest wind goes through northeast to northwest. In 1881 two such storms occurred; the first, at the end of September and beginning of October, in the latitude of Mazatlan; the second, at the end of October in the latitude of Manzanillo. In the latter the wind reached the high velocity of 100 miles per hour. Further details are wanting.

—The *Report of the State Board of Health of New Jersey* for 1883 is the seventh in its series. It is an octavo volume of 391 pages, of which pages 331–337 are devoted to quinquennial meteorological summaries from eight stations, three of which are stations of the Signal Service. The diversity of climate is considerable for so small an area. A study of the climate of Cape May has been made by Professor J. C. Smock, of New Brunswick, N. J. It is printed as part of a neat pamphlet issued, apparently, by the Cape May hotels. This is an interesting climatological study and brings out clearly the relatively small range of temperature at that resort, both in summer and in winter.

—*The Health Resorts of Colorado Springs and Manitou* is a pamphlet of 136 pages with several attractive illustrations. It is without date, but internal evidence places it in 1883. It is in two parts, the first of which is a "prize article" on the scenery and resources by Mrs. Simeon J. Dunbar. This fills 48 pages, and will prove serviceable to those who propose to visit the locality. The second part treats of climate in general, and that of these resorts in particular, from the therapeutical point of view, and is the work of Dr. S. Edwin Solly. The meteorological summaries are contributed by Professor F. H. Loud and occupy pages 99 to 112. They bring out clearly the characteristics of the climate which are, like most other elevated Rocky Mountain regions, remarkably mild, dry and clear. From the observations of a single month Mr. Loud works out a very pretty daily swing in the direction of the wind, but we fear that farther observations will show it to be illusory.

—In Mr. Edward Mawley's *The Weather of 1883 as Observed in the Neighborhood of London*, we have a careful study of the climate of the greatest city in the world. Mr. Mawley's own observations at Addiscombe and those of the Observatory at Greenwich are employed and the result is a pamphlet of 78 pages with a diagram giving a graphical comparison of the meteorological elements and the mortality of London in 1883, with the averages for many preceding years.

The winter of 1882–3 was warm and stormy and was followed by an unusually cold spring. The air temperature on March 24 was 20°.9 and that on grass 9°.2. There was quite a heavy snowstorm as late as April 23. The summer was unusually cold, unsettled and dry. The autumn was both moist and clear. The year at Addiscombe averaged 3 hours 45 minutes of sunshine daily and on 81 days no sunshine was recorded.

This pamphlet is the fifth annual issue and is to be commended as a model for similar work in this country.

—A lecture by Professor C. W. Hall of the University of Minnesota, entitled *Physiographic Conditions of Minnesota Agriculture*, and delivered before the State Horticultural Society, has been reprinted in pamphlet form. It is a neat study of the physical geography of the State, put in popular form. Professor Hall thinks that the streams of Minnesota carry off only a fraction over twenty-four per cent.

of the rainfall, and says that the remaining seventy-five per cent. must sink in the soil and be disposed of by subterranean streams. Mr. Hall has forgotten evaporation, which disposes probably of a very large part of this seventy-five per centum. We have before us the summary of observations on rainfall and evaporation in the City of Mexico. The total rainfall was 609^{mm}. The average daily evaporation in the shade was 2.2^{mm}. This would suffice to dispose of over 800^{mm} without requiring the service of underground drainage. Mexico is, we believe, in an independent waterbasin and the surface drainage is *nil*. We submit that before Mr. Hall can make his balance-sheet he must learn the amount of evaporation for Minnesota.

—Dr. N. de Konkoly records in the *Monthly Notices of the Royal Astronomical Society* the following spectroscopic observations of the red-colored sky at sunset January 9, $5^h\ 20^m$ P. M. The sky was examined at an altitude of between 5° and 10° with a Browning pocket-spectroscope, provided with a micrometer. In the less refrangible portion of the spectrum (yellow to red) five well-defined bands were seen. The broadest was that toward violet from D, but it was not the darkest. There was a second less refrangible than D, but this was a very indefinite band. At the boundary of the red and orange was a very deep black band, very well defined on both sides; less refrangible than that in the red was a very broad but pale band; less refrangible than this, nearly at the limit of the spectrum, was visible a very dark band, the blackest of all.

The positions of the bands were as follows:

1. From 584.6 to 567.5*
2. " 603.1 to 589.3
3. " 639.5 to 627.9*
4. " 711.0 to 661.7
5. " 739.0 to 711.9

The correction of the zero point of the micrometer was deduced by observation of the bright sodium line in an alcohol flame.

The bands marked * clearly correspond to the lines of atmospheric vapor.

—The April report of the Alabama Weather Service is at hand. It is a pamphlet of eight pages with a chart of the precipitation and another of the track of the tornado of April 15, 1884, near Auburn. The publication is issued through the state department of agriculture by P. H. Mell, Director, and is dated from the Agricultural and Mechanical College at Auburn. This publication is unusually interesting. Destructive fires occurred in Barbour Co., April 2, with high winds. A tornado passed near Springville, Blount Co., April 2. The cloud was shaped like "a big fodder-stack" inverted and seemed to have a ball of fire at its lower end. It was at a considerable elevation above the ground. Storms at considerable elevation in the atmosphere were observed in Henry Co. on the 15th, in Elmon Co. on the 19th, and in Perry Co. on one of these dates. In the first two great roaring was heard and the last was recognized as a whirlwind. The first was accompanied by hail which with wind did some damage; otherwise none of them were destructive. Of other tornadoes sweeping the surface, the following are noted: 60 miles S. W. of Chattanooga, Tenn., April 2, path 100 yards wide, 7 persons killed; near Hurley, Cherokee Co., March 25, 9 p. m., 400 yards wide, wedge-shaped cloud, brightly illuminated by electric flashes, two dwellings destroyed; Auburn, Lee Co., April 15, 12 p. m., electric display constant, damage mostly in Georgia. Remarkable rains occurred on the 15th, in Calhoun, Jefferson and Lauderdale Counties.

The service has reports from 23 stations, three being of the Signal Service.

—The organization of the Yale college observatory is now proceeding quietly. The control of the observatory will come directly under the corporation, the old board of managers being abolished. The bureaus of horology and thermometry, on account of their outside relations, will be placed on a business basis.

CORRESPONDENCE.

Barometers and Thunder-storms.

To the Editor:—I gladly welcome your excellent Journal in a field of science in which I have been much interested for several years.

In the May number Mr. H. M. Paul, writing on "Barometric Waves of very short Duration," expresses his surprise that they had not, so far as he knew, been noticed before.

I have in my possession a notice of them to which it would probably not be amiss to call your attention.

In the "Report of the British Association for the Advancement of Science" 1855, page 40 *bis*, I find the following mention of a paper presented by Mr. M. J. Johnson:—

"On examining and comparing the registrations of the thermometer and barometer, certain peculiarities present themselves which indicate a curious connexion between the course of these instruments and the state of the weather. The line which indicates the daily curve of temperature is sometimes serrated, sometimes even and continuous; and these appearances correspond to certain determinate states of the weather * * * from the end of March to the end of September, and never occurring even then during the night.

**Among the most remarkable results is a sudden rise of the barometer* amounting to .035 of an inch, and an increase of temperature of 1°, coincident with the occurrence of a thunder-clap which struck one of the churches in Oxford, July 14, 1855. A similar phenomenon took place during a thunder-storm on the 23rd of August, when the rise of the barometer was still greater, amounting to .049 inches; though the thunder-clap coincident with this latter rise was distant. * * * **During every occurrence of thunder or hail which had been recorded by his instruments, similar phenomena presented themselves, sometimes very minute but quite preceptible.*"

If there is not an increased attraction or repulsion due to electrical influence exerted between the earth and any body of air or vapor located near its surface and charged to an extremely high potential, it would seem to me in disaccordance with all we know of electrcial action. If there be an increase or decrease of attraction between the earth and any part of the atmosphere at such a time it must certaintly make itself felt by an increase or decrease of pressure, however minute, at the earth's surface immediately under such a body of air or vapor and any variation of potential must make itself felt by a variation of pressure.

That there should be a perceptible variation of pressure corresponding with the variation in the difference of potential between the earth and various portions of its atmosphere occurred to me several years ago, and I have since been gathering all the data I could, bearing on the subject. In a future article I shall adduce a number of facts which seem to favor such a conclusion.

H. H. Clayton, Jr.

*The italics are the present writer's.

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